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Basic Original Report

Cardiac and Pulmonary Dosimetric Parameters in Patients With Lung Cancer Undergoing Postoperative Radiation Therapy Across a Statewide Consortium

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Purpose: The recently published Lung Adjuvant Radiotherapy Trial (Lung ART) reported increased rates of cardiac and pulmonary toxic effects in the postoperative radiation therapy (PORT) arm. It remains unknown whether the dosimetric parameters reported in Lung ART are representative of contemporary real-world practice, which remains relevant for patients undergoing PORT for positive surgical margins. The purpose of this study was to examine heart and lung dose exposure in patients receiving PORT for non-small cell lung cancer across a statewide consortium.

Methods and Materials: From 2012 to 2022, demographic and dosimetric data were prospectively collected for 377 patients at 27 academic and community centers within the Michigan Radiation Oncology Quality Consortium undergoing PORT for nonmetastatic non-small cell lung cancer. Dosimetric parameters for target coverage and organ-at-risk exposure were calculated using data from dose-

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volume histograms, and rates of 3-dimensional conformal radiation therapy (3D-CRT) and intensity modulated radiation therapy (IMRT) utilization were assessed.

Results: Fifty-one percent of patients in this cohort had N2 disease at the time of surgery, and 25% had a positive margin. Sixty-six percent of patients were treated with IMRT compared with 32% with 3D-CRT. The planning target volume was significantly smaller in patients treated with 3D-CRT (149.2 vs 265.4 cm^3; $P < .0001$). The median mean heart dose for all patients was 8.7 Gy (interquartile range [IQR], 3.5-15.3 Gy), the median heart volume receiving at least 5 Gy (V5) was 35.2% (IQR, 18.5%-60.2%), and the median heart volume receiving at least 35 Gy (V35) was 9% (IQR, 3.2%-17.7%). The median mean lung dose was 11.4 Gy (IQR, 8.1-14.3 Gy), and the median lung volume receiving at least 20 Gy (V20) was 19.6% (IQR, 12.7%-25.4%). These dosimetric parameters did not significantly differ by treatment modality (IMRT vs 3D-CRT) or in patients with positive versus negative surgical margins.

Conclusions: With increased rates of IMRT use, cardiac and lung dosimetric parameters in this statewide consortium were slightly lower than those reported in Lung ART. These data provide useful benchmarks for treatment planning in patients undergoing PORT for positive surgical margins.

Introduction

Surgical resection remains the standard of care for patients with resectable nonmetastatic non-small cell lung cancer (NSCLC) with good performance status and limited comorbidities.[1] Despite many advances in adjuvant systemic therapy for these patients,[2-4] rates of locoregional recurrence remain high in patients with disease involving the regional lymph nodes or with positive surgical margins.[5] Initial efforts at leveraging postoperative radiation therapy (PORT) for locoregional treatment intensification demonstrated increased mortality in patients with pN0-N1 disease receiving PORT[6] but suggested a possible benefit in N2 patients.[7-9] This hypothesis was therefore prospectively tested in the randomized, phase 3 Lung Adjuvant Radiotherapy Trial (Lung ART) and PORT-C trials, with results revealing no disease-free survival benefit in patients undergoing PORT[10,11] and increased cardiac and pulmonary toxic effects in the PORT group on Lung ART.[11]

Although PORT is no longer routinely recommended for patients with N2 disease, it remains a standard treatment recommendation for patients with positive surgical margins. Given the high use of 3-dimensioanl conformal radiation therapy (3D-CRT) on Lung ART, it remains unclear whether the dosimetric parameters reported for dose exposure of organs at risk (OARs) are reflective of real-world practice with increased use of intensity modulated radiation therapy (IMRT). The purpose of this study was to analyze prospectively collected data from patients undergoing PORT for NSCLC within the Michigan Radiation Oncology Quality Consortium to determine whether heart and lung doses delivered in real-world practice are commensurate with doses reported on the Lung ART trial, which remains relevant to patients undergoing PORT for positive surgical margins.

Methods and Materials

This analysis included 377 patients from 27 academic and community centers in the state of Michigan who underwent surgical resection followed by postoperative radiation therapy for nonmetastatic NSCLC from 2012 to 2022. The clinical target volume, planning target volume (PTV), dose, and fractionation were at the discretion of the treating physician in accordance with accepted practice at the time of treatment. Demographic and dosimetric data were prospectively collected for these patients. Rates of 3D-CRT and IMRT use were analyzed. The mean heart dose (MHD), heart V5, heart V35, mean lung dose (MLD), lung V20, target volume, and minimum dose to 95% of the PTV were stratified by treatment modality and calculated using individual patient dose-volume histograms. Statistical comparisons of dosimetric data between treatment groups were performed using 2-sample *t* tests with SAS software, version 9.4 (SAS Institute, Cary, NC). Comparison with data reported from the Lung ART trial was performed qualitatively using aggregate published data.

Results

Patient demographics and tumor characteristics

In total, data were analyzed from 377 patients who underwent PORT after surgical resection for NSCLC from 2012 to 2022. The median age of all patients was 67 years. Fifty-five percent of patients were female. Most patients had adenocarcinoma (66%) or squamous cell carcinoma (30%). Thirty-three percent of patients had T1 disease, 37% had T2 disease, and 22% had T3 disease. Fifty-one percent of patients had N2 disease. Twenty-five percent of patients had a positive margin on final pathology (Table 1). Nineteen percent of patients (73 of 377) underwent radiation therapy more than 6 months after surgery, suggestive of salvage therapy for recurrent disease. Of these patients, 27 had N2-3 disease, 5 had positive margins, and 2 had both. Of the 82% of patients who received chemotherapy, 45% received concurrent and 55% received sequential chemotherapy.

Table 1 Patient demographics and tumor characteristics of patients receiving postoperative radiation therapy

Variable	Patients, no. (%)
Sex	
Female	209 (55.4)
Male	168 (44.6)
Histology	
Adenocarcinoma	247 (65.5)
Squamous cell carcinoma	112 (29.7)
Other	18 (4.8)
T stage	
T0	2 (0.5)
T1	123 (32.6)
T2	140 (37.1)
T3	84 (22.3)
T4	23 (6.1)
TX	5 (1.3)
N stage	
N0	120 (31.8)
N1	50 (13.3)
N2	191 (50.7)
N3	7 (1.9)
NX	9 (2.4)
Margin status	
Negative	259 (68.7)
Positive	93 (24.7)
Unknown	25 (6.6)
Treatment modality	
IMRT	248 (65.8)
3D-CRT	121 (32.1)
Unknown	8 (2.1)
Time to RT initiation after surgery, mo	
>6	73 (19.4)
≤6	304 (80.6)
Chemotherapy	
Concurrent	141 (37.4)
Sequential	169 (44.8)
None	67 (17.8)

Abbreviations: 3D-CRT = 3-dimensional conformal radiation therapy; IMRT = intensity modulated radiation therapy; RT = radiation therapy.

Tumor coverage and dose exposure to OARs

The median dose to 95% (D95%) of the PTV for all assessed patients was 54.2 Gy to a median PTV volume of 225.2 cm^3. Cardiac, pulmonary, and esophageal dose were calculated from patient dose-volume histograms. The median MHD for all patients was 8.7 Gy (interquartile range [IQR], 3.5-15.3 Gy), the median heart volume receiving at least 5 Gy (V5) was 35.2% (IQR, 18.5%-60.2%), and the median heart volume receiving at least 35 Gy (V35) was 9% (IQR, 3.2%-17.7%). The median mean lung dose (MLD) was 11.4 Gy (IQR, 8.1-14.3 Gy), and the median lung volume receiving at least 20 Gy (V20) was 19.6% (IQR, 12.7%-25.4%). The median mean esophagus dose was 19.4 Gy (IQR, 13.1-26.2 Gy), and the median minimum dose to the 2 cubic centimeters of esophagus receiving the highest dose (D2cc) was 52.4 Gy (IQR, 47.2-58 Gy). Twenty-five percent of patients received an MHD >15.3 Gy (Table 2). The average MHD and MLD were 10.3 and 11.2 Gy, respectively.

Dosimetric parameters by treatment modality

We next analyzed use of advanced treatment planning techniques in this patient cohort. Sixty-six percent of patients were treated with IMRT, compared with 32% treated with 3D-CRT. Median PTV volumes were smaller for 3D-CRT treatment plans (149 vs 265 cm^3; $P < .0001$). The median dose to 95% of the PTV was slightly lower for patients treated with 3D-CRT (53.7 vs 55 Gy; $P < .05$). The median MHD did not differ with treatment modality (9.5 Gy with IMRT vs 8 Gy with 3D-CRT). The heart V35 was numerically slightly lower in the IMRT group (8.3% vs 9.4%), whereas the heart V5 was slightly higher (38.9% vs 30.1%; $P < .01$). The median MLD and lung V20 were both slightly higher in patients treated with IMRT (MLD: 12.3 vs 10 Gy; $P = .0006$; lung V20[%]: 20.7% vs 17.6%; $P = .003$). Esophageal dose exposure did not differ by treatment modality (Table 3).

Similar patterns were observed in patients with N2-3 disease. Among this cohort, 68% of patients were treated with IMRT compared with 30% treated with 3D-CRT (2% unknown). Median PTV volumes were smaller for 3D-CRT plans compared with IMRT (203.4 vs 288.2 cm^3; $P < .0001$). The median MHD among patients with N2-3 disease was higher for patients treated with IMRT compared with 3D-CRT (10.6 vs 6.9 Gy; $P = .014$), as was heart V5[%] (39% vs 24%; $P < .0001$). No other measured cardiac or esophageal metrics differed significantly by treatment modality. Differences in MLD and lung V20[%] were similar to those observed in the entire cohort (MLD: 12.8 vs 11.1 Gy; $P = .004$; lung V20[%]: 21.7% vs 19.8%; $P = .02$) (Table 3).

OAR exposure in patients with positive surgical margins or N2+ disease

To determine whether the dose exposure of OARs observed within the entire cohort is representative of

Table 2 Dose exposure to thoracic organs at risk

Variable	25th percentile	Median	75th percentile
PTV volume, cm^3	119.5	225.2	357.6
PTV D95%, Gy	50	54.2	60
Mean heart dose, Gy	3.5	8.7	15.3
Heart V5, %	18.5	35.2	60.2
Heart V30, %	4.6	11.1	21
Heart V35, %	3.2	9	17.7
Mean lung dose, Gy	8.1	11.4	14.3
Lung V20, %	12.7	19.6	25.4
Mean esophagus dose, Gy	13.1	19.4	26.2
Esophagus D2cc, Gy	47.2	52.4	58

Abbreviation: D2cc = minimum dose to the 2 cc receiving the highest dose; D95% = minimum dose to 95% of target volume; PTV = planning target volume; V5 = volume of structure receiving 5 Gy; V20 = volume of structure receiving 20 Gy; V35 = volume of structure receiving 35 Gy.

exposure for patients with positive margins, we compared this population with those with negative margins. Twenty-five patients were excluded from this comparison owing to unknown margin status. As expected, the median dose to 95% of the PTV for patients with a positive margin was higher than for those with a negative margin (59.6 vs 53.9 Gy; $P = .07$). The median PTV volume did not differ between these 2 groups (200 vs 229 cm^3; $P = .45$). With the exception of a slightly higher heart V5 in patients with positive margins (47.9% vs 31.1%; $P < .05$), dose exposures to the heart, lung, and esophagus did not differ significantly by margin status (Table 4).

Similarly, patients were stratified by involved nodal burden (N0-1 vs N2-3). The median PTV volume was larger for patients with N2+ disease (258.2 vs 175.8 cm^3; $P = .0006$). This correlated with a trend toward a higher median MHD (9.2 vs 7.3 Gy; $P = .08$), but there was no significant difference in cardiac V5[%], V30[%], or V35 [%] (Table 4). The median MLD was higher for patients with N2+ disease (12.3 vs 9.3 Gy; $P < .0001$), as was the lung V20[%] (21.2% vs 15.2%; $P < .0001$). Esophageal exposure was also slightly greater in patients with N2+ disease, with a median mean esophageal dose of 21.7 versus 15.9 Gy ($P < .0001$) and a median esophageal D2cc of 53.3 versus 51.1 Gy ($P < .0001$) (Table 4).

OAR exposure in patients treated >6 months after surgery

Seventy-three patients underwent radiation therapy >6 months after surgery. In this cohort, there was a

Table 3 Comparison of organ-at-risk dose exposure for patients receiving IMRT versus 3D-CRT

Variable	Entire cohort, median (IQR)			Only patients with N2-3 disease, median (IQR)		
	3D-CRT	IMRT	*P* value	3D-CRT	IMRT	*P* value
PTV, cm^3	149.2 (79.1-269.5)	265.4 (155.1-414.8)	<.0001	203.4 (102.6-290.7)	288.2 (190.3-487.9)	<.0001
Dose to 95% PTV, Gy	53.7 (48.5-59.1)	55 (50.4-60)	.0148	50.3 (47.5-54.6)	53.8 (50.3-59.8)	.0005
Mean heart dose, Gy	8 (3.4-14.8)	9.5 (3.6-16.2)	.4435	6.9 (4.4-12.3)	10.6 (5.4-16.6)	.0136
Heart V5, %	30.1 (14.1-54.1)	38.9 (19.2-64.3)	.0012	24 (12.2-35.3)	39 (20.4-66.1)	<.0001
Heart V30, %	11.2 (4.6-24.6)	11 (4.6-20.1)	.434	9.1 (3.4-19.3)	12 (5.7-20.9)	.303
Heart V35, %	9.4 (3.2-20.2)	8.3 (3.2-17.4)	.1185	7 (2.5-17)	9 (4.4-18)	.7816
Mean lung dose, Gy	10 (6.9-12.9)	12.3 (9-14.8)	.0006	11.1 (8.6-12.9)	12.8 (10.4-14.8)	.0035
Lung V20, %	17.6 (10.6-22.6)	20.7 (13.6-26.2)	.0028	19.8 (13.7-23.2)	21.7 (17.3-26.7)	.0228
Mean esophagus dose, Gy	19.8 (13.1-27.3)	19 (13.2-25.5)	.4088	21.7 (18.5-28.7)	20.8 (16.9-27.6)	.8183
Esophagus D2cc, Gy	51.7 (46.3-57.2)	52.8 (47.4-58.1)	.4561	52 (49.7-55)	54 (51-57.9)	.1433

Abbreviations: D2cc = minimum dose to the 2 cc receiving the highest dose; 3D-CRT = 3-dimensional conformal radiation therapy; IMRT = intensity modulated radiation therapy; IQR = interquartile range; PTV = planning target volume; V5 = volume of structure receiving 5 Gy; V20 = volume of structure receiving 20 Gy; V35 = volume of structure receiving 35 Gy.

Table 4 Comparison of organ-at-risk dose exposure for patients with positive versus negative surgical margins

Variable	Median (IQR)			*P* value	Median (IQR)		*P* value
	All patients	Negative margin	Positive margin	Positive versus negative	N0-1	N2-3	N0-1 versus N2-3
PTV volume, cm^3	225.2 (119.5-357.6)	229 (116.1-345.3)	200.1 (119.5-365.5)	.4491	175.8 (84.4-306.7)	258.2 (152.5-380.6)	.0006
PTV D95%, Gy	54.2 (50-60)	53.9 (49.9-59.9)	59.6 (52.2-60.5)	.067	58.8 (51.2-60.3)	53.2 (49.9-59.5)	.0023
Mean heart dose, Gy	8.7 (3.5-15.3)	8.3 (3.4-13.9)	9.8 (3.7-17.2)	.2886	7.3 (1.8-15.3)	9.2 (5-14.9)	.077
Heart V5, %	35.2 (18.5 60.2)	31.1 (16.8-55.8)	47.9 (20.1-66.7)	.023	38.7 (17.3-60.7)	32.4 (18.8-58.5)	.7758
Heart V30, %	11.1 (4.6-21)	10.7 (4.4-20.3)	12.3 (5.1-22.5)	.4705	11 (3.4-22.4)	11.2 (5.2-20.1)	.8371
Heart V35, %	9 (3.2-17.7)	8.4 (3.2-17.6)	9.6 (2.7-19.9)	.5442	8.8 (2.7-18.2)	8.9 (3.8-17.7)	.6264
Mean lung dose, Gy	11.4 (8.1-14.3)	11.3 (8.2-14)	11.2 (6.9-14.5)	.3172	9.3 (6.7-13.7)	12.3 (9.9-14.4)	<.0001
Lung V20, %	19.6 (12.7-25.4)	19.3 (13-25.3)	19.3 (9-24.7)	.0942	15.2 (9.1-23.1)	21.2 (16.2-26.2)	<.0001
Mean esophagus dose, Gy	19.4 (13.1-26.2)	19.6 (13.9-26.4)	17.9 (11.4-23.8)	.079	15.9 (9.2-23.4)	21.7 (17-27.9)	<.0001
Esophagus D2cc, Gy	52.4 (47.2-58)	52.2 (47.5-57)	53.2 (45.3-59.7)	.6176	51.1 (32.8-59.7)	53.3 (50.9-56.9)	<.0001

Abbreviations: D2cc = minimum dose to the 2 cc receiving the highest dose; D95% = minimum dose to 95% of target volume; IQR = interquartile range; PTV = planning target volume; V5 = volume of structure receiving 5 Gy; V20 = volume of structure receiving 20 Gy; V35 = volume of structure receiving 35 Gy.

nonsignificant trend toward higher median D95% (59.9 vs 54 Gy; P = .10). There was no significant difference in PTV volume (220 vs 226.5 cm^3; P = .08), median MHD (9 vs 6.5 Gy; P = .38), median MLD (11.3 vs 11.8 Gy; P = .16), or any other cardiac, pulmonary, or esophageal dosimetric parameter evaluated between these 2 groups (Table 5).

Discussion

In this study of prospectively collected data from patients receiving postoperative radiation therapy for nonmetastatic NSCLC in real-world practice, we found that the mean heart and mean lung doses were lower than those recently reported on Lung ART.[11] Despite the differences in treatment modality (3D-CRT vs IMRT), dose exposure to these relevant OARs did not differ substantially when accounting for treatment technique (IMRT vs 3D-CRT) or surgical margin status.

The most common indications for PORT during the period in which these patients underwent treatment (2012-2022) were pN2 disease and positive surgical margins. In this treatment population, 50.7% of patients had pN2 disease. Before the publication of the recently reported randomized controlled Lung ART trial, PORT for pathologic N2 disease remained a controversial, but accepted, treatment in carefully selected patients. This trial reported no difference in 3-year disease-free survival between patients undergoing PORT versus observation, with higher rates of cardiac and pulmonary toxic effects in the PORT arm.[11] Importantly, most patients on this trial were staged with positron emission tomography, and most underwent treatment with 3D-CRT. The median mean heart and mean lung doses observed in our cohort were slightly lower (MHD, 8.7 Gy; MLD, 11.4 Gy) compared with averages reported on Lung ART (MHD, 13 Gy; MLD, 13 Gy). Because Lung ART reported average doses to OARs, to maintain consistency in comparison, we also analyzed the average MHD and MLD in our data set. The average MHD in our patient cohort was slightly higher than the median (10.3 vs 8.7 Gy) but was still lower than the 13-Gy average MHD reported on Lung ART. Average MLD in our cohort did not differ substantially from the median (11.2 vs 11.4 Gy). The lower MHD and MLD in our cohort compared with Lung ART were possibly related to both increased use of IMRT (66% in our cohort vs 11% on Lung ART) and an emphasis on cardiac dose sparing as a quality improvement initiative within the Michigan Radiation Oncology Quality Consortium.[12] It is also possible that elective nodal irradiation was used less frequently in our study population than on Lung ART, resulting in smaller treatment volumes and less OAR exposure.

It is unclear if the magnitude of difference in heart and lung doses observed between patients within MROQC

Table 5 Comparison of organ-at-risk dose exposure for patients treated within 6 months of surgery versus >6 months after surgery

Variable	Median (IQR)			*P* value
	All patients	Radiation ≤6 mo postsurgery	Radiation >6 mo postsurgery	Radiation <6 versus ≥6 mo postsurgery
PTV volume, cm^3	225.2 (119.5-357.6)	226.5 (126.8-372.6)	220 (113.7-306.8)	.077
PTV D95%, Gy	54.2 (50-60)	54 (50-60)	59.9 (51.4-60.1)	.0988
Mean heart dose, Gy	8.7 (3.5-15.3)	9 (3.7-16.2)	6.5 (2.7-14.3)	.3761
Heart V5, %	35.2 (18.5-60.2)	37.1 (19.4-60.6)	28.3 (11.7-60.2)	.2884
Heart V30, %	11.1 (4.6-21)	11.6 (4.8-21.3)	10.1 (2.7 18.8)	.2921
Heart V35, %	9 (3.2-17.7)	9.3 (3.4-18.5)	7.8 (2.0-16.2)	.2987
Mean lung dose, Gy	11.4 (8.1-14.3)	11.3 (7.8-14.2)	11.8 (8.9-14.8)	.1591
Lung V20, %	19.6 (12.7-25.4)	19.6 (12.1-25.1)	19.4 (13.9-27.2)	.3572
Mean esophagus dose, Gy	19.4 (13.1-26.2)	19.6 (13.3-26.2)	18.1 (12.9-24.3)	.5151
Esophagus D2cc, Gy	52.4 (47.2-58)	52.2 (47.3-57.1)	54.4 (47-60.6)	.3396

Abbreviations: D2cc = minimum dose to the 2 cc receiving the highest dose; D95% = minimum dose to 95% of target volume; IQR = interquartile range; PTV = planning target volume; V5 = volume of structure receiving 5 Gy; V20 = volume of structure receiving 20 Gy; V35 = volume of structure receiving 35 Gy.

and on Lung ART is sufficient to alter clinical outcomes; however, several recent studies analyzing the impact of heart dose reported adverse effects at cardiac doses lower than those reported on Lung ART. For instance, one retrospective analysis of 284 patients receiving PORT for NSCLC demonstrated a negative correlation between MHD and overall survival in a population of patients undergoing PORT for NSCLC with a median MHD of 11.2 Gy, most of whom were treated with IMRT. In this study, median overall survival for patients receiving >11.2 Gy MHD was 31.7 months, compared with 57.5 months for those receiving <11.2 Gy.[13] Similarly, a recent analysis of 125 patients receiving definitive chemoradiation for NSCLC with a median MHD of 11 Gy demonstrated increased risk of grade ≥3 major adverse cardiac events (MACEs) within 2 years after treatment, with an 18% 2-year cumulative incidence of MACEs in patients receiving >11 Gy MHD compared with 2% for those receiving <11 Gy. Predictive modeling in this study estimated an MHD per-Gy hazard ratio for MACEs of 1.07.[14]

Although PORT is not beneficial for patients with N2 disease, it remains a recommended treatment for patients with positive surgical margins who cannot undergo re-resection.[15] Twenty-five percent of patients in our study had a positive surgical margin. As expected, the median PTV dose in this group was higher than those with negative margins. However, PTV volume and dose exposure to critical thoracic OARs did not differ substantially in patients with a positive margin. The aforementioned toxicity data suggest that a significant proportion of patients in this population are at risk for cardiac toxic effects despite contemporary treatment with more advanced techniques, and maximizing cardiac dose reduction without sacrificing tumor coverage is critical to reducing the risk of toxic effects. Our prior work has demonstrated that targeted education regarding the importance of minimizing cardiac dose in patients undergoing thoracic RT is correlated with decreased MHD over time, which occurred independent of IMRT use and without sacrificing tumor coverage.[12] This effort applied to all patients receiving thoracic RT for NSCLC within MROQC, which may partly account for the low median MHD observed in this series.

As expected, the total PTV size was significantly larger for patients receiving radiation for N2-3 disease compared with N0-1 disease and numerically larger than for patients with positive margins. This correlated with higher pulmonary and esophageal dose exposure. Interestingly, however, there was only a trend toward increased median MHD, and all other cardiac parameters were unchanged. Although the extent to which elective nodal radiation was used in these patients is unknown, the significantly smaller PTV volume for patients with N0-1 disease and OAR dose exposure consistent with prior reports of involved field irradiation[16] both suggest that many of these patients likely received involved field radiation.

Comparing dose exposure to OARs based on 3D vs IMRT treatment modality within the MROQC data set, we did not observe substantial differences in MHD, MLD, lung V20, mean esophagus dose, or esophageal D2cc. The heart V35 was slightly lower in patients treated with IMRT, whereas the heart V5 was slightly higher, as would be expected. Importantly, the median PTV volume in the 3D-CRT cohort was significantly smaller than the median volume in the IMRT cohort, suggesting that one possible explanation for the similarity in dose exposure between techniques is the potential for increased use of 3D-CRT

for smaller targets or those that are anatomically distant to critical OARs, with IMRT use more common for larger targets in closer proximity to OARs. These findings persisted when the analysis was limited to patients with N2-3 disease, with the exception of a slightly larger difference in median MHD.

Nineteen percent of patients underwent radiation therapy more than 6 months after surgery, suggesting that this cohort likely received salvage radiation therapy as opposed to adjuvant radiation. This is supported by a median D95% consistent with a salvage radiation dose in this group. Although the potential benefit of radiation therapy is greater in the salvage setting, which may influence considerations during treatment planning, no significant differences were noted in the cardiac, pulmonary, or esophageal dosimetric parameters analyzed in this study.

One primary limitation of this study is that it was observational in nature. Although dosimetric and demographic data were prospectively collected, details on treatment rationale were not included, and therefore, treatment indication cannot be assessed at the individual patient level. Because of this, the indication for treatment in the patients who did not have N2-3 disease, a positive surgical margin, or salvage treatment cannot be elucidated. Similarly, details of treatment planning, such as the clinical target volume and PTV expansions used or elective nodal irradiation versus involved field irradiation, were at the discretion of the treating physicians and therefore subject to a degree of heterogeneity. Another limitation is that the comparisons with previously published work are not based on individual patient data from the published trial and therefore are not amenable to statistical comparison, although the clinical relevance of such a comparison would be unclear.

Conclusion

Although PORT for patients with node-positive NSCLC is no longer recommended owing to a lack of clinically meaningful benefit, it is still often used in patients with positive surgical margins. The dosimetric data presented here from a contemporary cohort of patients receiving PORT for NSCLC provide useful benchmarks for heart and lung dose in these patients.

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